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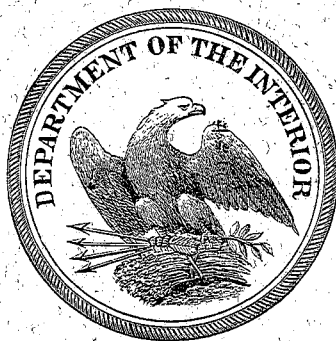
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MONOGRAPHS

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VOLUME XLIX



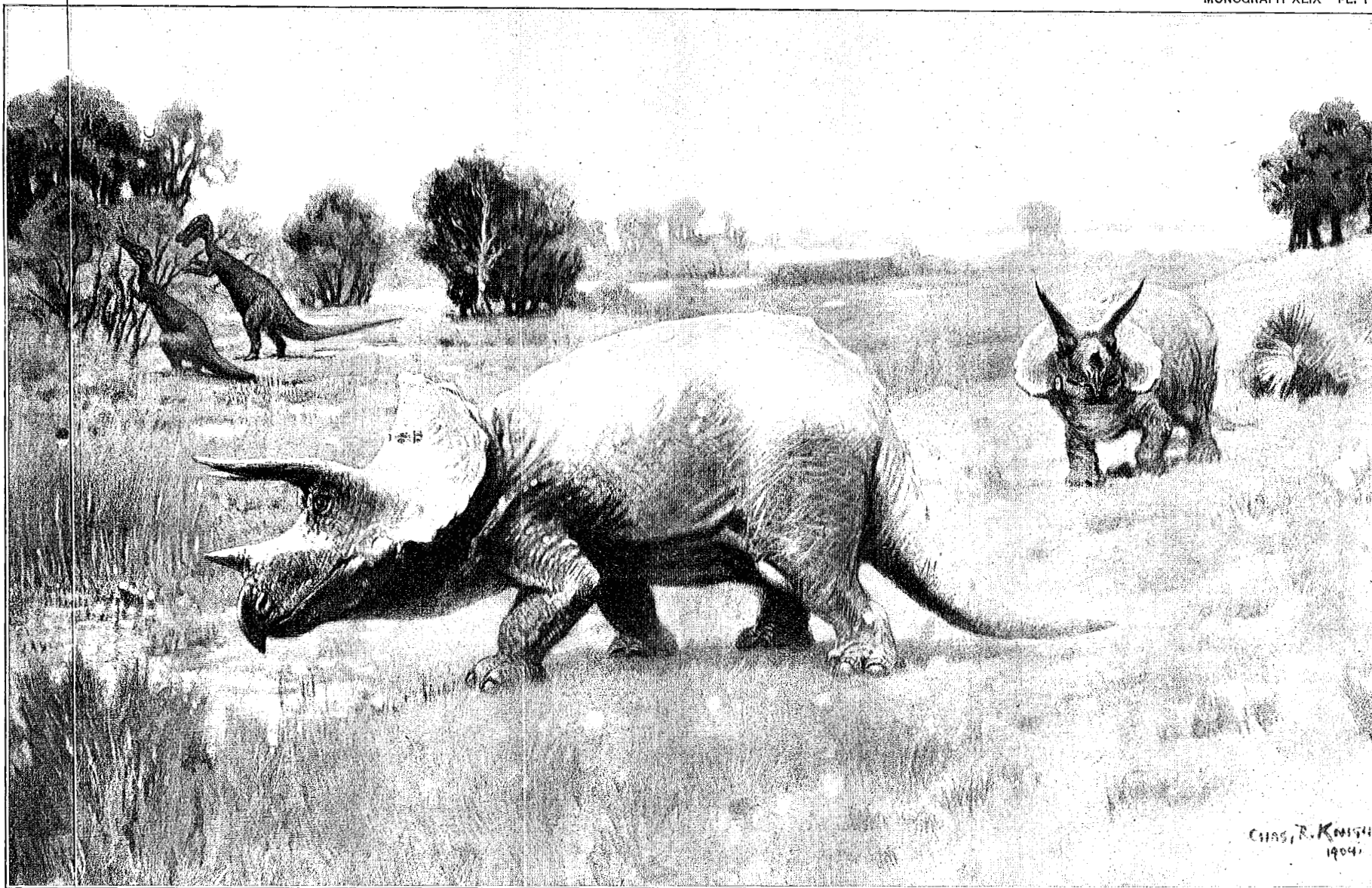
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RESTORATION OF TRICERATOPS; TRACHODON IN THE DISTANCE.

From painting made under Mr. Hatcher's direction by Charles R. Knight.

Original in Carnegie Museum, Pittsburg, Pa.

59TH CONGRESS }
2d Session }

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UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

THE CERATOPSIA

BY

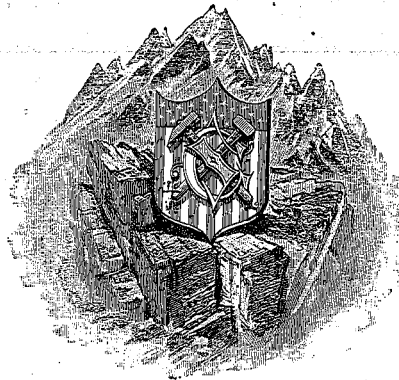
JOHN B. HATCHER

BASED ON PRELIMINARY STUDIES BY

OTHNIEL C. MARSH

EDITED AND COMPLETED BY

RICHARD S. LULL



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ERRATA.

[Monograph XLIX of the United States Geological Survey.]

- Page 11. Eighth line of text from bottom, for "1871 E" read "4739."
- Page 11. Third line of text from bottom, after the word "Type" insert "No. 5457, U. S. National Museum."
- Page 12.. To list of genera and species add "34. *T. sulcatus* Marsh. Am. Jour. Sci., vol. 39, May, 1890, p. 422. Type No. 4276, U. S. National Museum."
- Page 33. In legend of fig. 30, for "2116" read "1201."
- Page 37. In legend of fig. 32, for "2065" read "2416."
- Page 39. In legend of fig. 34, for "2065" read "2416."
- Page 57. Fig. 62, left pubis is not that of type.
- Page 65. Nos. 1, 2, and 3 of fig. 74 are of specimen No. 5793, U. S. National Museum.
- Page 115. Eleventh line from top, for "1871 E" read "4739."
- Page 170. Tenth line from top, for "1871 E" read "4739."

NOTE: Concerning statements on pages 139 and 140 relative to the condition of skull and jaw of specimen No. 4928, it should be said that no record has yet been found of the receipt at the National Museum of the missing parts. They probably became separated from the other material in packing and in their fragmental condition can not now be accurately identified.

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16
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FOREWORD TO THE MONOGRAPHS ON VERTEBRATE PALEONTOLOGY.

By HENRY FAIRFIELD OSBORN.

While vertebrate paleontologist of the United States Geological Survey Prof. Othniel Charles Marsh originated the large conception of a series of paleontological monographs worthy of the remarkable nature and preservation of the ancient life of North America. His plan was to make very complete collections of certain orders and families of vertebrates, to illustrate them in the most artistic manner, and to describe and discuss them in detail. At the time of his death, in 1899, the execution of this great plan was left in the following condition.

- | | |
|-------------------------|---|
| 1. Odontornithes..... | Published in 1880. |
| 2. Dinocerata..... | Published in 1884. |
| 3. Sauropoda..... | Incomplete; preliminary bulletins published. |
| 4. Ceratopsia..... | Unpublished: preliminary bulletins published. |
| 5. Stegosauria..... | Unpublished; preliminary bulletins published. |
| 6. Brontotheriidae..... | Unpublished; preliminary bulletins published. |

In 1900 the Director of the United States Geological Survey invited me to take general oversight of the preparation of the four incomplete monographs, and all the unpublished work which had been prepared by my distinguished predecessor was put into my hands after revision and report by a special committee. It was found to consist entirely of 204+ carefully prepared lithographic plates, of drawings and wood engravings, some partial bibliographies, and about 100 pages of rough pencil notes and memoranda. The supervision and execution of these illustrations had involved years of labor. There was no manuscript whatever. All record of the numerous and important observations which Professor Marsh had made of these groups of animals he had already published in preliminary bulletins, chiefly in the *American Journal of Science* and in his two contributions to the Survey publications, "The dinosaurs of North America" (1896), and "Vertebrate fossils of the Denver Basin" (1897).

The entire text of the four monographs therefore remained to be written. To treat exhaustively the materials which had been collected under Professor Marsh's direction and to cover the progress of the many succeeding years of exploration and research by other authors constituted only a part of the work which remained to be done. Many new plates and supplemental illustrations were evidently necessary. Geological as well as paleontological exploration in the field was absolutely needful in order to supplement the very meager data which had been preserved as to the geological conditions and stratigraphic distribution of these animals—data hardly less essential to their philosophical comprehension than the data afforded by the fossils themselves.

After very considerable thought I decided upon the following as the most desirable uniform plan of treatment for each volume and each group:

Section 1. *History of discovery* and of the gradual development of knowledge of the structure and affinities of the group.

Section 2. *Definitions and relationships.* General definition of the group and general morphology or anatomy as compared with that of other groups.

Section 3. *Geological data.* General geological conditions and stratigraphic succession of the stages and horizons in which the remains of the group are found.

Section 4. *Systematic revision.* Systematic revision of the types of each taxonomic rank in the chronological order of their original description, including (1) the parts constituting the type and cotype, if any; (2) the locality and geological level so far as recorded; (3) the present location and museum number of the type; (4) the author's original definitions and descriptions of the type or types. This method of treatment allows little room for originality, but it is the prerequisite of the monographic research of section 5; it disposes once for all of troublesome questions of priority, and if accurately and impartially done is final and furnishes an invaluable reference work for all future research. This section should precede the original morphologic and taxonomic section, instead of following it as arranged by Marsh in his monograph on the Dinocerata.

Section 5. *Morphology and taxonomy.* In this section the animals are rearranged in their natural classification according to the observations and conclusions of the authors; they are treated successively, according to their geological sequence, if ascertained, or if not, according to the sequence indicated by increasing specialization of structure; the orders, families, genera, and species are redefined if necessary; valid forms are distinguished; the synonymous names are eliminated. The entire structure and functions of different parts of the body of each type are considered and carefully discussed.

It is evident that section 5 differs from section 4 in containing a large amount of original matter, consisting of the author's conclusions, which are subject to modification by the opinions of others and by future discovery.

Section 6. *Phylogeny and biology.* In this final original section the phylogenetic history of the group is traced from its probable origin. The phylogenetic relationships of the animals to one another and to other forms are now rendered clearer through the full preceding discussion of their anatomy. Their environment is considered, their habits, their external form and appearance, and finally the rise and fall of the group, and the probable causes of its extinction.

Having thus determined upon this general plan of treatment for these monographs, it remained to decide how they could be most carefully and expeditiously prepared. The experience of my predecessor made it apparent that a division of labor was absolutely essential. I therefore invited Mr. F. A. Lucas to undertake the Stegosauria, and Mr. J. B. Hatcher to undertake the Ceratopsia, I myself to undertake the Sauropoda and Brontotheriidae.

There could be no question as to either the justice or the wisdom of assigning the present monograph on the Ceratopsia to John Bell Hatcher. His discovery and collection of these animals was, with the exception of his explorations in Patagonia, the greatest single achievement of his remarkable life. Under Professor Marsh's direction, he had devoted four most arduous years to bringing together the magnificent specimens of these horned dinosaurs for the United States Geological Survey and National Museum and for the Yale University Museum.

Mr. Hatcher was delighted to undertake the difficult piece of comparison and research involved in a complete restudy of the Ceratopsia, and entered upon it in July, 1902, with his usual ardor and thoroughness. Except during brief intermissions in the field he worked at this task full time almost daily for two years in addition to discharging his duties during other hours as curator of vertebrate paleontology in the Carnegie Museum. Examining the types, supervising the further preparation of the fossils, visiting all the museums, preparing a very large number of additional drawings, carefully writing and revising his text—this was his occupation for two years. Finally, he was on the very threshold of the pleasantest portion of the work, the conclusion of the systematic and morphological section, and in sight of the rearrangement, classification, and philosophical treatment of the group, when he was stricken down on July 3, 1904.

Much work remained to be done. It was necessary that the monograph should be completed by a third author, and that that author as editor should not alter but should leave the work distinctively Mr. Hatcher's.

Prof. Richard S. Lull, of Yale University, has most sympathetically and successfully accomplished this task. Part I (pp. 1-157) is Mr. Hatcher's, entirely unrevised, the few editor's notes being inserted in brackets. Part II (pp. 159-198) is Professor Lull's, but includes, so far as known, Mr. Hatcher's opinions on the matters treated, as well as very extensive quotations from his writings. It also includes a very considerable amount of original matter by Professor Lull.

I trust that this volume may prove to be a lasting monument to the rare and noble spirit of John Bell Hatcher.

MON XLIX—07—II

EXPLORATIONS OF JOHN BELL HATCHER FOR THE PALEONTOLOGICAL MONOGRAPHS OF THE UNITED STATES GEOLOGICAL SURVEY, TOGETHER WITH A STATEMENT OF HIS CONTRIBUTIONS TO AMERICAN GEOLOGY AND PALEONTOLOGY.

By HENRY FAIRFIELD OSBORN.

I. SCIENTIFIC EXPLORATIONS.

While working in the mines of Iowa, John Bell Hatcher^a had made a small collection of Carboniferous fossils. These he brought to New Haven in 1880 and showed to Prof. George J. Brush, who later introduced him to Prof. Othniel C. Marsh. After graduation from the Sheffield Scientific School he impressed upon Professor Marsh the fact that he wanted to collect and study fossils—that he was willing to work at almost any salary. Marsh recognized his ability and planned to send him at once into the western field. Thus was started Hatcher's career in paleontology.

Hatcher began his first collecting tour on June 25, 1884, near Long Island, Kans. Here he was for a time associated with Mr. Charles H. Sternberg in work in the upper Miocene deposits of the Loup Fork, but after an apprenticeship of a month he began to collect independently. He remained in Kansas until late in November, then traveled south, and spent the winter months until the latter part of March, 1885, around Wichita Falls, Tex., collecting Permian reptiles. These collections are in the Yale Museum.

In 1885 he made a second tour to and about Long Island, Kans., collecting chiefly in the upper Miocene formation as field assistant on the United States Geological Survey. During the two seasons in this region he sent to Professor Marsh, partly for the Yale University Museum and partly for the National Museum, through the United States Geological Survey, a large number of boxes containing chiefly Miocene rhinoceroses. Little or none of this material has yet been described.

In the meantime Professor Marsh was planning his monograph on the lower Oligocene family, the Brontotheriidae, for which he had already[†] collected some materials. The variety and richness of these animals were still unknown and unsuspected. Marsh assigned to Hatcher the further assembling of material for this monograph, a task which he accomplished with extraordinary success. During the seasons of 1886, 1887, and 1888 he spent fifteen months in the field and collected 105 nearly complete *Titanotherium* skulls and many portions of skeletons and disarticulated bones, besides the remains of many other associated animals. These were collected chiefly for the United States Geological Survey. In 1888 he extended his exploration from Long Pine to Chadron, Nebr., and to the vicinity of Hermosa, S. Dak. Here he laid the

^a John Bell Hatcher was born at Cooperstown, Brown County, Ill., October 11, 1861. He died July 3, 1904, while engaged in the preparation of this monograph upon the Ceratopsia. Other purely biographical matter will be found in the obituaries by Scott, McGee, Holland, Schuchert, Eaton, and Osborn as follows:

Scott, W. B. John Bell Hatcher. *Science*, new ser., vol. 20, No. 500, July 29, 1904, pp. 139-142.

Holland, W. J. In Memoriam: John Bell Hatcher. *Ann. Carnegie Mus.*, vol. 2, No. 4, 1904, pp. 597-604.

Eaton, George F. Obituary in *Am. Jour. Sci.*, 4th ser., vol. 18, August, 1904, pp. 163-164.

Schuchert, Charles. John Bell Hatcher. *Am. Geologist*, vol. 35, No. 3, March, 1905, pp. 131-141.

McGee, W. J. Hatcher's Work in Patagonia. *Nat. Geog. Mag.*, vol. 8, No. 11, November, 1897, pp. 319-322.

Osborn, Henry F. John Bell Hatcher, his life and works. In preparation.

The writer is also indebted to Messrs. Charles Schuchert, T. W. Stanton, and O. A. Peterson for their kind revision of the present article.

foundation of his first very exact observations of the stratigraphic succession of the species of titanotheres. This he subsequently made the subject of an important paper in which these beds were subdivided into three levels. In this paper he refers to his work as follows:

Early in the season of 1886 it became apparent that certain forms of skulls were characteristic of certain horizons in the beds. This fact showed the importance of keeping, so far as possible, an exact record of the horizon from which each skull or skeleton was taken. From actual measurement the vertical range of the Titanotheriidae was found to be about 180 feet. For convenience in keeping a record of horizons the beds were divided into three divisions of 60 feet each, and each of these three divisions was subdivided into three divisions of 20 feet each. The different skulls and skeletons, when dug out, were each given a separate letter or number, and this letter or number was placed in that subdivision of the beds from which the skull or skeleton was taken.

In 1901 Hatcher again made a tour of these beds in the interests of the Brontotheriidae monograph, which had been transferred after the death of Professor Marsh to Professor Osborn's hands; he was accompanied by N. H. Darton, of the Geological Survey, and Prof. Eberhard Fraas, of Stuttgart. By means of this second trip practically every species of titanotheres was placed in its exact geological level.

During the late autumn and winter months of 1887 Hatcher made collections in the older Tertiary^a deposits around Washington, D. C., Richmond, Va., and at the Egypt coal mine in North Carolina, searching for the remains of *Belodon* and *Dromatherium* in the upper Triassic beds of that locality, which resulted in the finding of a fine specimen of *Belodon*. In the meantime a new problem came before the Survey; the age of the beds of the so-called Potomac formation had not been satisfactorily determined. Here again Hatcher was successful in procuring considerable dinosaur material, from which Marsh, in a series of papers, attempted to prove that these beds were of Jurassic age.^b

He concluded the season of 1888 with a trip to the north—to the Cretaceous beds of the Judith River region of Montana. In this region, on the upper Missouri, Cope had explored in 1875 and 1876, finding the remains of *Monoclonius recurvicornis* and other species of the still unrecognized suborder Ceratopsia. Hatcher procured remains of several skulls of related horned dinosaurs, on which Marsh established the new genus *Ceratops*.

In the same autumn—that of 1888—Hatcher's attention was first called to a pair of very large horn cores found 35 miles from Lusk, Wyo., and early in the spring of 1889 this incident led to the discovery of the great locality in Converse County, Wyo., which enabled Marsh to establish and define the great suborder Ceratopsia, and fixed the scene of Hatcher's labors from 1889 to 1892.

Hatcher's very important geological observations, together with his characteristically brief and modest account of his labors, are found in one of his first published papers, entitled "Some localities for Laramie mammals and horned dinosaurs," from which the following is quoted:

In the nearly four years spent by the writer in working these beds, 31 skulls and several fairly complete skeletons of horned dinosaurs were secured, besides two quite complete skeletons of *Diclonius* (*Claosaurus*), about 5,000 isolated jaws and teeth of Laramie mammals, and numerous remains of other dinosaurs, turtles, lizards, birds, and fishes, as well as extensive collections of fresh-water invertebrates from the same beds. In all, over 300 large boxes of fossils were collected for the United States Geological Survey and are now carefully stored in the Yale Museum, many of them as yet unopened.

This brief summary conveys but a faint idea of the energy, persistence, and skill involved in this work. The great skulls, themselves inclosed in hard sandstone matrices, give the best impression; one huge box (about 10 feet long, 5 feet wide, and 6 feet deep), containing the largest known skull of *Triceratops*, had to be lifted out of a ravine 50 feet deep and hauled for more than 40 miles over a trackless country to the railroad.

Here also he made his important discovery of the remains of Cretaceous mammals in great abundance, only two or three imperfect specimens having previously been found. This discovery he described as follows:

^a It is my impression that these collections were mostly from the Eocene.—T. W. S.

^b The dinosaur material on which these conclusions were based was all from near the base of the Potomac, and the evidence for the Jurassic age of even this portion has been questioned. The upper Potomac beds are now known to be well up in the Cretaceous.—T. W. S.

The small mammals are pretty generally distributed but are never abundant, and on account of their small size are seen with difficulty. They may be more frequently found in what are locally known as "blow-outs" and are almost always associated with garpike scales and teeth, and teeth and bones of other fish, crocodiles, lizards, and small dinosaurs. These remains are frequently so abundant in "blow outs" as to easily attract attention, and when such a place is found careful search will almost always be rewarded by the discovery of a few jaws and teeth of mammals. In such places the ant-hills, which in this region are quite numerous, should be carefully inspected, as they will almost always yield a goodly number of mammal teeth. It is well to be provided with a small flour sifter with which to sift the sand contained in these ant-hills, thus freeing it of the finer materials and subjecting the coarser material remaining in the sieve to a thorough inspection for mammals. By this method the writer has frequently secured from 200 to 300 teeth and jaws from one ant-hill. In localities where these ants have not yet established themselves, but where mammals are found to be fairly abundant, it is well to bring a few shovelfuls of sand with ants from other ant-hills, which are sure to be found in the vicinity, and plant them on the mammal locality. They will at once establish new colonies, and if visited in succeeding years will be found to have done efficient service in collecting mammal teeth and other small fossils, together with small gravels, all used in the construction of their future homes. As an instance of this I will mention that when spending two days in this region in 1893, I introduced a colony of ants in a mammal locality, and on revisiting the same place last season I secured in a short time from the exterior of this one hill 33 mammal teeth.

In the meantime, in 1891, Hatcher was made assistant to the chair of geology in Yale University. During these highly successful explorations for the remains of Ceratopsia he was in the service partly of Professor Marsh and partly of the United States Geological Survey; so that the collections have been divided between the Yale University Museum and the National Museum in Washington.

He was now at the age of 32, and had been at work nine years without giving any intimation of his original ability as a thinker and writer. He now began his career as a publicist, producing his first paper entitled "The Ceratops beds of Converse County, Wyoming," in the American Journal of Science, February, 1893.

In the spring of 1893 Hatcher accepted a call to Princeton University as curator of vertebrate paleontology and assistant in geology.

For the seven succeeding years he was associated with Prof. W. B. Scott, who has given a full account of his great services to paleontology in Princeton University, which, perhaps, surpassed those he had rendered to his alma mater. His work included three divisions: (1) The exploration of the western Tertiaries, (2) the arrangement of the entire collection of mammalian fossils in the E. M. Museum of Geology, and (3) the expeditions to Patagonia. Professor Scott says:

The most important work which Hatcher undertook during his connection with Princeton was his exploration of Patagonia in the years 1896 to 1899. The plan was all his own and was not proposed to the geological department until everything was nearly ripe for action. He procured the greater part of the necessary funds, and, with characteristic generosity, was himself a liberal contributor. How successful this great undertaking was is very generally known and needs not to be repeated here. Great credit for his success is due to Messrs. Peterson and Colburn, who were associated with Hatcher in the work, but the soul of the enterprise was Hatcher himself. In his "Narrative of the expeditions" he has left an extremely well written and interesting account of these explorations.

In addition to the "Narrative and geography," Hatcher had undertaken to write reports upon the geology and also upon the fossil *Litopterna* and *Marsupialia*. How much of this material can be put into shape for publication can not yet be told. In any event he has raised for himself an enduring monument in these volumes, which owe their existence to him, however much or little may be his verbal contribution to their contents.

Hatcher finally returned home in the autumn of 1899, and on February 1, 1900, accepted the position of curator of paleontology and osteology in the museum of the Carnegie Museum of Pittsburg. As soon as he was installed he began to lay out, in consultation with Director W. J. Holland of that museum, plans for very extensive paleontological collections, and for the four succeeding summers he carried on explorations in the Western States and Territories. Through the generosity of Mr. Andrew Carnegie the work begun by Dr. J. L. Wortman in the season of 1899 in the upper Jurassic of Wyoming around Sheep Creek was continued under Hatcher's direction. He initiated renewed exploration in the Upper Cretaceous of Converse County, Wyo., in the *Dæmonelix* beds of the upper Miocene of Nebraska, and in the Oligocene White River formations of South Dakota and Nebraska. These divisions of the work were organized on a large scale under Messrs. Peterson, Gilmore, Utterback, and Douglass. In the following year he began the further exploration of the Jurassic dinosaur quarries of Marsh and Cope near

Canyon City, Colo., which had already yielded the types of *Camarasaurus*, *Diplodocus*, and many other Sauropoda. Here, as in every other region, Hatcher made not only important discoveries of fossils but invaluable geological observations. In 1902 the Carnegie Museum explorations were continued in Nebraska, in the Jurassic deposits of the Bighorn Mountains in Wyoming, and in the Titanotherium beds of Montana. In the season of 1903 these explorations were continued, and parties were sent also into the chalk or Niobrara deposits of western Kansas.

In 1903 also, the question of the age of the Judith River beds of Montana having come up, Hatcher was employed by the United States Geological Survey for a special expedition with Mr. T. W. Stanton, of the United States Geological Survey, and they finally settled this important problem.

During this period the problem of the sunken continent of Antarctica came to the fore among both geologists and biologists. Two expeditions were projected from Great Britain. Hatcher had carefully studied all the literature pertaining to the South Atlantic and had found notes which convinced him that vertebrate fossils were to be found on one of these islands. He was accordingly fired with the desire to join the proposed Scottish expedition and carried on a long correspondence with the promoters of the project of this expedition, which finally was abandoned. He then developed plans for an Antarctic exploration, which he laid before the Carnegie Institution of Washington.

This was with him a period of great activity. During these four years he published no less than 32 scientific papers, including his most important memoirs on *Diplodocus*, *Haplocanthosaurus*, and the splendid quarto of 314 pages entitled "Narrative and geography," volume 1 of the Reports of the Princeton Expeditions to Patagonia.

During the years 1902-1904 Hatcher was working at the rate of six to seven hours a day on the present monograph on the Ceratopsia, further account of which is given in his own preface to this volume and in the pages by Osborn and Lull.

II. SCIENTIFIC CONTRIBUTIONS.

I. GEOLOGY AND STRATIGRAPHY.^a

1. The Ceratops beds of Converse County, Wyo., February, 1893.
2. The Titanotherium beds, March, 1893.
4. On a small collection of vertebrate fossils from the Loup Fork beds of northwestern Nebraska, with note on the geology of the region, March, 1894.
8. Some localities for Laramie mammals and horned dinosaurs, February, 1896.
11. The Cape Fairweather beds; a new marine Tertiary horizon in southern Patagonia, September, 1897.
12. On the geology of southern Patagonia, November, 1897.
18. Sedimentary rocks of southern Patagonia, February, 1900.
27. The Jurassic dinosaur deposits near Canyon City, Colo., 1901.
33. Origin of the Oligocene and Miocene deposits of the Great Plains, 1902.
37. A correction of Professor Osborn's note entitled "New vertebrates of the mid-Cretaceous," November, 1902.
39. The Judith River beds, March, 1903.
40. L'âge des formations sédimentaires de Patagonie, by Florentino Ameghino. Criticism. June, 1903.
43. Relative age of the Lance Creek (Ceratops) beds of Converse County, Wyo., the Judith River beds of Montana, and the Belly River beds of Canada, June, 1903.
44. The stratigraphic position of the Judith River beds and their correlation with the Belly River beds of Canada. Joint note with T. W. Stanton. August 14, 1903.
46. Osteology of *Haplocanthosaurus*, with description of a new species, and remarks on the probable habits of the Sauropoda and the age and origin of the Atlantosaurus beds, November, 1903.
48. Narrative and geography. Reports of the Princeton University Expeditions to Patagonia, 1896-1899, vol. 1, 1903.
49. An attempt to correlate the marine with the nonmarine formations of the Middle West, 1904.
50. Geology and paleontology of the Judith River beds, by T. W. Stanton and J. B. Hatcher, with a chapter on the fossil plants, by F. H. Knowlton. Bull. U. S. Geol. Survey No. 257, 1905.

A glance at the titles of the eighteen papers cited above gives at once an impression of the breadth and extent of Hatcher's geological observations and of his energy and initiative as a

^aSee citations in full at the end of this sketch, pp. xxv-xxvi.

traveler and explorer. It will be noticed that the series embraces the Jurassic, the Cretaceous, and the Tertiaries of western North America and of the extremity of South America. The reader of these papers is impressed as much with the wealth of detail as with the power of generalization and imagination of past geological conditions, which is especially manifested in his development of the eolian v. the lake-basin theory of deposition in the western Oligocene and Miocene, in his discussion of the stratigraphic relations of the Judith River beds, in his discussion of the geological history of Patagonia, and in his final geological paper, delivered at the anniversary meeting of the Philosophical Society in 1904, "An attempt to correlate the marine with the nonmarine formations of the Middle West."

Fresh from his explorations for the Ceratopsia and Brontotheriidae were the first two papers which came from his pen, "The Ceratops beds of Converse County," settling their Upper Cretaceous age, and "The Titanotherium beds," establishing the geological and stratigraphical sequence of various species of titanotheres, as well as the thickness and subdivision of the Titanotherium beds into three levels. In 1894 his "Note on the geology of northwestern Nebraska" contained the first of his observations on the relations of the Loup Fork and Equus beds, which were continued during a number of years and were brought to a conclusion in his remarkable paper of 1902, entitled "Origin of the Oligocene and Miocene deposits of the Great Plains," in which he strongly combated the lake-basin theory and advocated the theory of flood-plain and eolian deposition.

The first fruits of the Princeton Patagonian Expedition was a short paper entitled "The Cape Fairweather beds," in which he described this new marine horizon overlying the Santa Cruz deposits. These four years of exploration resulted in his entire rearrangement of the Upper Cretaceous and Tertiary rocks of Patagonia, as set forth in his two papers "On the geology of southern Patagonia" (November, 1897) and "Sedimentary rocks of southern Patagonia" (February, 1900). The latter contains his final conclusions and is of very great importance. In this paper (1) he states that the Eocene was a period of depression, in which there was no fresh-water deposition; (2) he removes the entire series of typical Patagonian beds from the Eocene, where it was formerly placed, and refers it to late Oligocene and early Miocene; (3) he states that the Pyrotherium beds, as that term has been used by Doctor Ameghino, include a series of deposits of varying age from Eocene to Pleistocene—deposits of limited area appearing on eroded surfaces of the Guaranitic Cretaceous beds, and thus producing the confusion which has existed regarding the age of the *Pyrotherium* fauna; (4) he states that the Santa Cruz beds immediately and conformably overlie the Patagonian beds.

The following table exhibits Hatcher's views as to the sequence of the various sedimentary rocks of Patagonia and their age as indicated by paleontologic and stratigraphic evidences:

Sedimentary rocks of Patagonia.

Pleistocene.	Shingle formation.
Pliocene.	Cape Fairweather beds.
Miocene.	Santa Cruz beds.
	Patagonian beds.
Oligocene.	Upper lignites.
	Magellanian beds.
Eocene.	<i>Wanting.</i>
Cretaceous.	Guaranitic beds.
	Lower lignites.
	Variegated sandstones.
	Upper conglomerates.
	Belgrano beds.
	Lower conglomerates.
	Gio beds.
	<i>Wanting.</i>
Jurassic?	Mayer River shales.

His observations thus included the Mesozoic section as far down as the Jurassic and, with the exception of a few multituberculate teeth in the Guaranitic beds, completely excluded the mammals from the Upper Cretaceous, where they had been placed.

In 1902 Hatcher again began discussing the Upper Cretaceous vertebrate-bearing horizons of North America, and especially the relations of the Judith River and Laramie beds. Already (American Naturalist, February, 1896) he had affirmed that the Judith River beds were certainly older than the Ceratops beds of Converse County, Wyo., and that the dinosaurs from the Judith River belonged to smaller and less specialized forms than those from the latter locality. Osborn, without observing this note, had subsequently reached the same conclusion. In an animated series of notes and papers Hatcher discussed this question, and finally in June, 1903, accompanied Mr. T. W. Stanton, paleontologist of the United States Geological Survey, in a field study of the Judith River beds and associated formations in Montana and southern Assiniboia. They demonstrated that the Judith River beds represent a fresh-water deposit 600 feet in thickness which is intercalated in the true marine beds of Fort Pierre age, which, therefore, both underlie and overlie the Judith River. This conclusion entirely cleared up this vexed question, explained the discrepancies in the notes of different observers, and established the practical synchronism of these beds with the Belly River deposits of British Columbia, as suggested on geological grounds by Dawson and on faunalistic grounds by Osborn and Lambe.

Hatcher's chief contribution to the Jurassic is his admirable paper published in 1901, "The Jurassic dinosaur deposits near Canyon City, Colo.," in which he shows the sequence in the deposition and evolution of the dinosaurian remains found at this point and clearly states the difficulties which arise in our attempts to correlate these strata with the Upper Jurassic or Lower Cretaceous. His concluding paragraph, while not of final value, is so interesting and suggestive that it may be quoted entire:

The difficulty, it seems to me, lies in the want of a realization of the fact that different conditions prevailed simultaneously over different though often adjacent regions and caused the simultaneous deposition of different materials. Along the streams and about the shores of the greater bodies of water deposits of sandstone would predominate, while in the quieter waters, and especially offshore, the finer materials would be thrown down to form the clays and shales of the same series. Wherever we find these shore deposits constituting the Jurassic strata we encounter the same difficulty in separating the Jura from the Dakota, for sedimentation there seems to have been continuous throughout the two periods, and we are brought to the question as to the equivalents at such localities of the Lower Cretaceous. Could not the rocks of these two formations, in part at least, represent the fresh-water and land equivalents of the marine deposits belonging to the Lower Cretaceous? Fresh-water and marine conditions must have always prevailed, as at present, at the same time over different parts of the earth's surface, though thus far there has been little attempt on the part of geologists and paleontologists to correlate them, each series having as a rule been assigned to a distinct period in the time scale, though it is none the less certain that every marine formation has been accompanied by contemporaneous though more constricted fresh-water deposits, and that remnants, at least, of most of such deposits are still preserved can hardly be doubted; indeed, we may be quite positive that every fresh-water or eolian deposit of whatever age has its marine equivalent, and the writer sees no reason why the lower members of the dinosaur beds of Garden Park should not be the equivalents of the marine Baptonodon beds farther north, while the upper dinosaur beds of the same region and the entire series of dinosaur beds farther north would become the equivalents of the marine Lower Cretaceous. That the lowermost dinosaur beds of Garden Park are of an earlier age than those of Como Bluff, in southern Wyoming, and Piedmont, S. Dak., as well as of the other localities lying to the north, will, I think, be clearly demonstrated when we come to make a comparative study of the dinosaur remains from each. From the foregoing remarks it will readily appear that in the Garden Park region the problem of separating the Jura from the Cretaceous becomes a difficult one; the top of the Dakota becomes the natural dividing line; whether considered lithologically or paleontologically, and I have no doubt that these difficulties will be further enhanced by the discovery of dinosaur horizons throughout the entire upper series of sandstones and shales which we now consider as belonging to the Dakota. This is almost sure to follow as a reward for a patient and careful search in these beds, and will be most welcome as adding one more link in connecting the long gap which at present exists between Jurassic and Laramie dinosaurs.

2. GEOGRAPHY AND NARRATIVE.

14. Patagonia, November, 1897.
15. The third Princeton expedition to Patagonia, October, 1899.
16. Explorations in Patagonia, November 18, 1899.
19. Some geographic features of southern Patagonia; with a discussion of their origin, February, 1900.
20. The Carnegie Museum paleontological expeditions of 1900, November, 1900.
23. The lake systems of southern Patagonia, March, 1901.
36. Field work in vertebrate paleontology at the Carnegie Museum for 1902, November 7, 1902.
45. Vertebrate paleontology at the Carnegie Museum, October 30, 1903.
48. Narrative and geography: Reports of the Princeton University expeditions to Patagonia, 1903.

The explorations in Patagonia afforded Hatcher an opportunity for exhibiting his rare ability as an explorer, geographer, and field naturalist. He published five papers, culminating in his splendid volume entitled "Narrative and Geography." Many portions of this work, with their combination of observations upon nature in all its aspects, remind one strongly, in philosophical method of treatment and in style of presentation, of Darwin's "Voyage of H. M. S. Beagle." It is impossible to briefly summarize this magnificent work.

His preliminary papers, "Some geographic features of southern Patagonia, with a discussion of their origin," "Explorations in Patagonia," and "Lake systems of Patagonia," the last treating of his discovery of several new lakes, are all covered in more extensive form in the Narrative.

The following extract is from an appreciative notice by W J McGee:

Returning from the trip into the interior, Hatcher, with his companion, made a voyage through the Strait of Magellan and about Tierra del Fuego, in the course of which many new observations were made on the natural history, geology, paleontology, and ethnology of the region. The various routes traversed are indicated on Hatcher's map, through which an idea of the extent of the journeys may be gained. He returned to Princeton in July, 1897.

As indicated by his article, Hatcher's energies were by no means limited to the collection of specimens; indeed, he utilized his opportunities for geographic, geologic, and ethnologic study in a notably successful manner. The geographic results are stated summarily, though with excess of modesty, in the paragraphs prepared for this magazine, while the preliminary results of the geologic and paleontologic researches appear in several articles in the American Journal of Science and the American Geologist.

3. PALEONTOLOGY, COMPARATIVE ANATOMY.

3. A median-horned rhinoceros from the Loup Fork beds of Nebraska, March, 1894.
4. On a small collection of vertebrate fossils from the Loup Fork beds of northwestern Nebraska, with note on the geology of the region, March, 1894.
5. Discovery of *Diceratherium*, the two-horned rhinoceros, in the White River beds of South Dakota, May, 1894.
6. On a new species of *Diplacodon*, with a discussion of the relations of that genus to *Telmatotherium*, December, 1895.
7. Discovery in the Oligocene of South Dakota of *Eusmilus*, a genus of saber-toothed cats new to North America, December, 1895.
10. Recent and fossil tapirs, March, 1896.
13. *Diceratherium proavium*, November, 1897.
17. The mysterious mammal of Patagonia, *Grypotherium domesticum*, by Rudolph Hauthal, Santiago Roth, and Robert Lehmann Nitsche. Review, December 1, 1899.
21. Vertebral formula of *Diplodocus* (Marsh), November 30, 1900.
24. Some new and little known fossil vertebrates, 1901.
25. On the cranial elements and the deciduous and permanent dentitions of *Titanotherium*, 1901.
26. *Sabal rigida*, a new species of palm from the Laramie, 1901.
28. *Diplodocus* Marsh; its osteology, taxonomy, and probable habits, with a restoration of the skeleton, July, 1901.
29. On the structure of the manus in *Brontosaurus*, December 27, 1901.
30. A mounted skeleton of *Titanotherium dispar* Marsh, 1902.
31. Structure of the fore limb and manus of *Brontosaurus*, 1902.
32. The genera and species of the Trachodontidae (Hadrosauridae, Claosauridae) Marsh, 1902.
34. Oligocene Canidae, September, 1902.
35. Discovery of a musk-ox skull (*Ovibos cavifrons* Leidy) in West Virginia near Steubenville, Ohio, October 31, 1902.
38. A new sauropod dinosaur from the Jurassic of Colorado, February 21, 1903.
41. A new name for the dinosaur *Haplocanthus* Hatcher June, 1904.
42. Discovery of remains of *Astrodon* (*Pleurocalus*) in the Atlantosaurus beds of Wyoming, June, 1903.
46. Osteology of *Haplocanthosaurus*, with description of a new species and remarks on the probable habits of the Sauropoda and the age and origin of the Atlantosaurus beds, November, 1903.
47. Additional remarks on *Diplodocus*, 1903.
50. Geology and paleontology of the Judith River beds, by T. W. Stanton and J. B. Hatcher, with a chapter on the fossil plants, by F. H. Knowlton. Bull. U. S. Geol. Survey No. 257, 1905.
51. Two new species of Ceratopsia from the Laramie of Converse County, Wyo., by J. B. Hatcher. [Edited by Richard S. Lull.] 1905.
52. The Ceratopsia, a monograph, by J. B. Hatcher, based on preliminary studies by Othniel Charles Marsh, edited and completed by Richard S. Lull. [Biographical notice by Henry Fairfield Osborn.] Mon. U. S. Geol. Survey, vol. 49, 1907.

In the decade between 1894 and 1904, crowded as it was with administration, with organization of western parties, with his actual labors as a collector, and his two journeys to Patagonia, Hatcher contributed to vertebrate paleontology no less than 25 papers, varying in length from a page to his monograph of 392 manuscript pages on the Ceratopsia. Although he had had little early training as a comparative anatomist, he exhibits the same keen powers of observation as in geology and exceptional ability in selecting new and important characters. This last quality is especially manifested in his work on the rhinoceroses and titanotheres. The form described by Cope and Osborn as *Aphelops* he soon distinguished as *Teleoceras* by its possession of a terminal horn on the nasals. Similarly he was the first to observe rudimentary horns in *Aceratherium tridactylum*, and to determine that this animal was the ancestor of *Diceratherium*, a point which had been overlooked by Osborn. His independence of mind was illustrated in breaking away from the phylogeny and terminology of the Eocene titanotheres as partly established by Earle, Marsh, and Osborn, and founding a new genus *Dolichorhinus*, showing that this genus was not directly ancestral to the titanotheres, as Osborn had supposed, but was a collateral form, and that the true ancestry was to be sought rather in another genus, *Mantoceras*, which he also established, acting upon a suggestion of Wortman.

Very valuable single papers showing his ability as an osteologist are his "Recent and fossil tapirs" (1896), "Cranial elements of *Titanotherium*" (1901), and "A mounted skeleton of *Titanotherium*" (1902). Of much value also are his papers "Some new and little known fossil vertebrates," including his description of *Trigonias* (1901), and his memoir "Oligocene Canidae" (1902).

By far his most important paleontological contributions, however, were those which enriched our knowledge of dinosaurs, especially of the group of Sauropoda. He took an active

part in the restoration of the splendid skeleton of *Diplodocus carnegiei*, which had been collected for the Carnegie Museum. His observations on this genus resulted in a series of similar papers and culminated in his fine memoir "*Diplodocus* Marsh, its osteology, taxonomy, and probable habits, with a restoration of the skeleton." Similarly he made an important addition to our knowledge of *Brontosaurus*, especially as to the structure of the fore limb and manus, correcting some of the observations of Osborn. The chief opportunity which presented itself to him in this group came with the surprising discovery in Canyon City of an entirely new and very primitive type of sauropodous dinosaurs, to which he gave the name *Haplocanthosaurus*. His final studies on this form are included in a second memoir, "*Osteology of Haplocanthosaurus*." This memoir concludes with a very interesting discussion of the probable habits of the Sauropoda, in which Hatcher strongly contended that they were of amphibious life, and a final discussion of the age and origin of the Atlantosaurus beds.

4. ETHNOLOGY.

22. The Indian tribes of southern Patagonia, Tierra del Fuego, and adjoining islands, January, 1901.

Hatcher's observations on the native Indian tribes of southern Patagonia are succinctly summarized in his "Narrative" (pp. 261-275), where he gives valuable photographs of the big and rather amiable Tehuelches, the so-called giant race of Patagonia.

5. SCIENTIFIC CONTRIBUTIONS OF J. B. HATCHER, IN CHRONOLOGICAL ORDER.^a

1. The Ceratops beds of Converse County, Wyoming. *Am. Jour. Sci.*, 3d ser., vol. 45, Feb., 1893, pp. 135-144.
2. The Titanotherium beds. *Am. Naturalist*, vol. 27, Mar., 1893, pp. 204-221, figs. 1-3.
3. A median-horned rhinoceros from the Loup Fork beds of Nebraska. *Am. Geologist*, vol. 13, Mar., 1894, pp. 149, 150.
4. On a small collection of vertebrate fossils from the Loup Fork beds of northwestern Nebraska, with note on the geology of the region. *Am. Naturalist*, vol. 28, Mar., 1894, pp. 236-248, figs. 1, 2, pls. i, ii.
5. Discovery of *Diceratherium*, the two-horned rhinoceros, in the White River beds of South Dakota. *Am. Geologist*, vol. 13, May, 1894, pp. 360, 361.
6. On a new species of *Diaplocodon*, with a discussion of the relations of that genus to *Telmatotherium*. *Am. Naturalist*, vol. 29, Dec., 1895, pp. 1084-1090, figs. 1, 2, pls. xxxviii, xxxix.
7. Discovery, in the Oligocene of South Dakota, of *Eusmilus*, a genus of saber-toothed cats new to North America. *Ibid.*, pp. 1091-1093, pl. xl.
8. Some localities for Laramie mammals and horned dinosaurs. *Ibid.*, vol. 30, Feb., 1896, pp. 112-120, pl. iii.
9. The Princeton scientific expedition of 1895. *Princeton Coll. Bull.*, vol. 8, pp. 95-98.
10. Recent and fossil tapirs. *Am. Jour. Sci.*, 4th ser., vol. 1, Mar., 1896, pp. 161-180, figs. 1, 2, pls. ii-v.
11. The Cape Fairweather beds; a new marine Tertiary horizon in southern Patagonia. *Ibid.*, vol. 4, Sept., 1897, pp. 246-248, 1 fig.
12. On the geology of southern Patagonia. *Ibid.*, Nov., 1897, pp. 327-354, figs. 1-11, and sketch map.
13. *Diceratherium proavatum*. *Am. Geologist*, vol. 20, Nov., 1897, pp. 313-316, pl. xix.
14. Patagonia. *Nat. Geog. Mag.*, vol. 8, Nov., 1897, pp. 305-319, 2 figs. and map, pls. 35-37.
15. The third Princeton expedition to Patagonia. *Science*, new ser., vol. 10, Oct. 20, 1899, pp. 580, 581. (Unsigned article.)
16. Explorations in Patagonia. *Sci. Am.*, vol. 81, Nov. 18, 1899, pp. 328, 329, 9 figs.
17. The mysterious mammal of Patagonia, *Grypotherium domesticum*, by Rudolph Hauthal, Santiago Roth, and Robert Lehmann Nitsche. (*Revista del Museo de La Plata*, vol. 9, pp. 409-474.) Review. *Science*, new ser., vol. 10, Dec. 1, 1899, pp. 814, 815.
18. Sedimentary rocks of southern Patagonia. *Am. Jour. Sci.*, 4th ser., vol. 9, Feb., 1900, pp. 85-108, pl. i.
19. Some geographic features of southern Patagonia; with a discussion of their origin. *Nat. Geog. Mag.*, vol. 11, Feb., 1900, pp. 41-55, 3 figs., pl. 2.
20. The Carnegie Museum paleontological expeditions of 1900. *Science*, new ser., vol. 12, Nov. 9, 1900, pp. 718-720.
21. Vertebral formula of *Diplodocus* (Marsh). *Ibid.*, Nov. 30, 1900, pp. 828-830.
22. The Indian tribes of southern Patagonia, Tierra del Fuego, and adjoining islands. *Nat. Geog. Mag.*, vol. 12, Jan., 1901, pp. 12-22, 4 figs.
23. The lake systems of southern Patagonia. *Bull. Geog. Soc., Phila.*, vol. 2, pp. 139-145, map; and *Am. Geologist*, vol. 27, Mar., 1901, pp. 167-173, pl. xvi.
24. Some new and little known fossil vertebrates. *Ann. Carnegie Mus.*, vol. 1, 1901, pp. 128-144, fig. 1, pls. i-iv.
25. On the cranial elements and the deciduous and permanent dentitions of *Titanotherium*. *Ibid.*, pp. 256-262, fig. 1, pls. vii, viii.

^a This bibliography is based on one prepared by Hatcher's brother-in-law, O. A. Peterson.

26. *Sabal rigida*; a new species of palm from the Laramie. Ibid., pp. 263, 264, fig. 1.
27. The Jurassic dinosaur deposits near Canyon City, Colorado. Ibid., pp. 327-341, figs. 1-5.
28. *Diplodocus* Marsh; its osteology, taxonomy, and probable habits, with a restoration of the skeleton. Mem. Carnegie Mus., vol. 1, July, 1901, pp. 1-63, figs. 1-24, pls. i-xiii.
29. On the structure of the manus in *Brontosaurus*. Science, new ser., vol. 14, Dec. 27, 1901, pp. 1015-1017.
30. A mounted skeleton of *Titanotherium dispar* Marsh. Ann. Carnegie Mus., vol. 1, 1902, pp. 347-355, pls. xvi-xviii.
31. Structure of the fore limb and manus of *Brontosaurus*. Ibid., pp. 356-376, figs. 1-14, pls. xix, xx.
32. The genera and species of the Trachodontidae (Hadrosauridae, Claosauridae) Marsh. Ibid., pp. 377-386.
33. Origin of the Oligocene and Miocene deposits of the Great Plains. Proc. Am. Philos. Soc., vol. 41, 1902, pp. 113-131.
34. Oligocene Canidae. Mem. Carnegie Mus., vol. 1, Sept., 1902, pp. 65-108, figs. 1-7, pls. xiv-xx.
35. Discovery of a musk-ox skull (*Ovibos cavifrons* Leidy) in West Virginia, near Steubenville, Ohio. Science, new ser., vol. 16, Oct. 31, 1902, pp. 707-709, 1 text fig.
36. Field work in vertebrate paleontology at the Carnegie Museum for 1902. Ibid., p. 752, Nov. 7, 1902.
37. A correction of Professor Osborn's note entitled "New vertebrates of the mid-Cretaceous." Ibid., Nov. 21, 1902, pp. 831, 832.
38. A new sauropod dinosaur from the Jurassic of Colorado. Proc. Biol. Soc. Washington, vol. 16, Feb. 21, 1903, pp. 1, 2.
39. The Judith River beds. Science, new ser., vol. 17, Mar. 20, 1903, pp. 471, 472.
40. L'âge des formations sédimentaires de Patagonie, by Florentino Ameghino. (Anales Soc. Cientif. Argentina, pp. 3-231, Buenos Aires, 1903.) Criticism. Am. Jour. Sci., 4th ser., vol. 15, June, 1903, pp. 483-486.
41. A new name for the dinosaur *Haplocanthus* Hatcher. Proc. Biol. Soc. Washington, vol. 16, June 25, 1903, p. 100. [*Haplocanthosaurus*.]
42. Discovery of remains of *Astrodon* (*Pleurocebus*) in the Atlantosaurus beds of Wyoming. Ann. Carnegie Mus., vol. 2, June, 1903, pp. 9-14, figs. 1-6.
43. Relative age of the Lance Creek (Ceratops) beds of Converse County, Wyoming, the Judith River beds of Montana, and the Belly River beds of Canada. Am. Geologist, vol. 31, June, 1903, pp. 369-375.
44. (With T. W. Stanton.) The stratigraphic position of the Judith River beds and their correlation with the Belly River beds. Science, new ser., vol. 18, Aug. 14, 1903, pp. 211, 212.
45. Vertebrate paleontology at the Carnegie Museum. Ibid., Oct. 30, 1903, pp. 569, 570.
46. Osteology of *Haplocanthosaurus*, with description of a new species and remarks on the probable habits of the Sauropoda and the age and origin of the Atlantosaurus beds. Mem. Carnegie Mus., vol. 2, Nov., 1903, pp. 1-72, figs. 1-28, pls. i-v.
47. Additional remarks on *Diplodocus*. Ibid., pp. 72-75, figs. 1, 2, pl. vi.
48. Narrative and geography. Reports of the Princeton University Expeditions to Patagonia, 1896-1899, vol. 1, 1903, pp. xvi+314, plates and map.
49. An attempt to correlate the marine with the nonmarine formations of the Middle West. Proc. Am. Philos. Soc., vol. 43, No. 178, p. 341.
50. Geology and paleontology of the Judith River beds. By T. W. Stanton and J. B. Hatcher. With a chapter on the fossil plants by F. H. Knowlton. Bull. U. S. Geol. Survey No. 257, 1905.
51. Two new species of Ceratopsia from the Laramie of Converse County, Wyoming, by J. B. Hatcher. [Edited by R. S. Lull.] Am. Jour. Sci., 4th ser., vol. 20, Dec., 1905, pp. 413-419, pls. xii-xiii.
52. The Ceratopsia, a monograph. By J. B. Hatcher. Based on preliminary studies by Professor Othniel Charles Marsh. Edited and completed by Richard S. Lull. [Biographical notice by Henry Fairfield Osborn.] Mon. U. S. Geol. Survey, vol. 49, 1907.

EDITOR'S PREFACE.

Mr. Hatcher was within a few weeks of completing the manuscript of this monograph when his hand was arrested by death. The typewritten manuscript, when placed in the editor's hands, was found to end abruptly in the middle of a sentence in the course of the description of *Triceratops (Sterrholophus) flabellatus* (p. 147). Diligent search brought to light some more pencil manuscript in Hatcher's hand, carrying the work through the systematic part as far as page 157 of this monograph. This portion, referring to the genera *Diceratops*, *Torosaurus*, and *Nodosaurus*, did not, as a consequence, have the advantage of the author's final revision.

Part II (pp. 159-198) has been prepared by the editor, the labor being increased by the preliminary necessity of mastering Hatcher's ideas and conclusions so far as known. This portion has been actually compiled, whenever possible, from the author's published or written opinions, the editor's purpose being to make the monograph, in so far as possible, Hatcher's own.

In the preparation of the geological portion the joint writings of Hatcher and Stanton, of Stanton and Knowlton, and of L. M. Lambe have been largely used, while in Part II many of the editor's own ideas and conclusions were, perforce, added where Hatcher's views could not be learned from any of his writings.

The author makes frequent reference to a chapter devoted to the revision of the genera and species. This chapter (represented by the generic and specific summary in Part II), so important from the systematic and nomenclatural standpoint, he unfortunately did not write, and the difficult duty of preparing it has devolved upon the editor.

The text figures were virtually completed under the author's supervision, only 12 having been added by the editor. The plates were less complete, however, as several, showing the comparative anatomy, had not been prepared. These have been drawn by Mrs. Lull and, it is hoped, are in accordance with Mr. Hatcher's general plan. The lettering on all the plates except Pls. XVIII-XXV and XLVI was inserted under the direction of the editor.

It should be understood that Hatcher by no means exhausted the possibilities of the subject, a fact which no one appreciated more fully than he. Much remains to be learned concerning material already in the museums but as yet only partially prepared. The need of further exploration and collection in the Judith River beds and their geological equivalent, the Belly River of Canada, where the earliest known Ceratopsia are found, is urgent if we would have an adequate understanding of the group.

The editor has been aided in his undertaking by Professor Schuchert, of Yale University Museum, by Mr. L. M. Lambe, of the Canadian Geological Survey, by Dr. W. D. Matthew, of the American Museum, and by the authorities of the National Museum in Washington. To Prof. Henry Fairfield Osborn especial gratitude is due for his expression of trust in placing so important a task in the editor's hands and for his material aid in the loan of specimens and in the final revision of the manuscript.

RICHARD S. LULL.

PALEONTOLOGICAL LABORATORY, YALE UNIVERSITY MUSEUM,

July, 1906.

AUTHOR'S PREFACE.

When, at the request of Prof. H. F. Osborn, who succeeded the late Prof. O. C. Marsh as chief of the division of vertebrate paleontology of the United States Geological Survey, I undertook to complete Professor Marsh's unfinished volume on the Ceratopsia, it was understood that the work would be attended with certain difficulties that probably would not have presented themselves had Professor Marsh lived to complete the volume himself. The vast collection brought together at New Haven, though in part belonging to the United States Geological Survey, would doubtless, had he lived, have remained intact, for the most part, at least, until such time as he had completed his studies, thus enabling him to study the collection together as a unit instead of separated and divided between two distinct institutions.

Considerable inconvenience has been experienced in the preparation of the present volume by reason of the fact that the material upon which it is based is for the most part scattered in the museums of four different institutions, with none of which the present author is connected, thus necessitating considerable loss of time in travel and rendering it quite impossible to bring together for comparison the types of closely related species. By far the most serious difficulty, however, has been experienced from the lack of sufficient preparation of the large collection of skulls and other material made by the present writer under the direction of the late Professor Marsh, many of which still remain unopened in the original boxes in which they were packed in the field. To render this entire collection fully accessible for purposes of study is a work which of itself would require the services for several years of a considerable force of skilled preparators and would entail an expenditure of both time and money far in excess of that allotted for the preparation of the present volume, which, notwithstanding its title, should be regarded rather as an introduction to the study of the Ceratopsia than as a final report on that interesting group of dinosaurs. It is hoped, however, that in the text and figures not a little new light of interest to the specialist will be thrown on the structure of the Ceratopsia as a group and on the relations of the various genera and species, while at the same time it is believed that those pages relating to the history of the discovery of the Ceratopsia, their probable habits, the conditions under which they lived, the causes which led to their extermination, the causes and conditions of the preservation of their remains, the geology and physiography of the region in which they are found, and the difficulties experienced in collecting such huge fossils, the skulls alone of some of which, when prepared for shipment, having weighed upward of 3 tons, will be of interest to the layman.

Unfortunately only 19 of the lithographic plates planned by the original author for the present volume were completed prior to his death, and, since the Survey has discontinued lithography for illustrations of this character, that uniformity and artistic effect which is shown in the plates of Professor Marsh's other monographs are wanting in the present volume. It is believed, however, that this loss has been at least partially offset by the series of text figures, reproduced from pen-and-ink drawings, which illustrate the text and represent many of the more abstruse anatomical details with possibly greater fidelity than would have resulted from the use of lithographs, where, as too often happens, detail of character is sacrificed for artistic effect.

For aid rendered and for privileges of study in the preparation of the present volume I am indebted to the authorities of various museums. From the late Dr. Charles Emerson Beecher I received every possible aid and opportunity in studying the magnificent collection of Ceratopsia belonging to Yale University. To Dr. George P. Merrill and Mr. Frederick A.

Lucas, of the United States National Museum, I am indebted for many courtesies and for the free use of the large collections of horned dinosaurs belonging to that institution, second only in importance to the collections in the museum of Yale University. To the Canadian Geological Survey I am under obligations for the original drawings and electrotypes used in the illustrations accompanying the memoir by Prof. H. F. Osborn and Mr. L. M. Lambe, entitled "On Vertebrata of the mid-Cretaceous of the Northwest Territory," published as Part II of Volume III of Contributions to Canadian Paleontology of the Canadian Geological Survey. My studies of the collections of the Canadian Survey have been greatly facilitated by Mr. Lambe. To Professor Osborn, of the American Museum of Natural History, New York, I am under obligations for the privilege of studying the collections brought together by the late Professor Cope, which, notwithstanding their fragmentary nature, are of much interest in that they contain a number of types, pertaining more especially to earlier and more primitive forms collected by Professor Cope and his assistants in the Judith River beds of northern Montana.

To the patience and skill of Mr. Sydney Prentice is largely due the excellent series of pen-and-ink figures which accompany and illustrate the text and which set forth with clearness and detail most of the more important cranial and other features, the determination of which is made possible by the large and splendid collection of skulls brought together by the late Professor Marsh and now in the museum of Yale University.

I am indebted to Messrs. C. W. Gilmore, Hugh Gibb, T. A. Bostwick, A. W. Vankirk, and Normann Boss for assistance in preparing certain portions of the material in the Yale and National museums for study.

Above all, however, for whatever of merit there is in the present volume science is mainly indebted to that Nestor of American vertebrate paleontology, the late Prof. Othniel Charles Marsh, whose generosity to a large extent made it possible to bring together the collections upon which the volume is based. Nor did his contributions to the subject end here, for, as appears on the title-page, the present memoir is based on his preliminary studies, and although he left no manuscript aside from his published papers on the Ceratopsia he provided a fund of information in the nature of finished and unfinished drawings, as well as symbols and letters on specimens indicating the character and relations of different parts of the skeleton as he had determined them. These have been of the greatest service, and it is a pleasure to accord the fullest acknowledgment therefor.

The more important collections belonging to the Yale University Museum and the United States National Museum, upon which this volume is chiefly based, were for the most part collected by me, and their value was fully recognized and appreciated by Professor Marsh, as will readily appear from an examination of almost any of his publications. Yet I feel impelled by a sense of justice to give recognition also to others who, as companions or assistants, shared with me throughout at least a portion of the four years spent in bringing together this collection the hardships and vicissitudes of camp life, and who are therefore equally deserving of whatever credit may be due for the accomplishment of that portion of the work. Among these I would mention the late Dr. C. E. Beecher, Messrs. O. A. Peterson, W. H. Utterback, A. L. Sullins, and W. H. Burwell as being especially worthy of recognition.

The lithographic plates were executed by the late Mr. E. Crisand from drawings by Mr. Frederick Berger, also deceased. Both of these gentlemen served Professor Marsh for many years, the former as lithographer and the latter as delineator, materially increasing the value of his publications by their skill and patience. The pencil drawings in the plates and text are also by Mr. Berger. Most of the more important of the pen-and-ink drawings in the text and plates are by Mr. Sydney Prentice; a few, however, representing material now in the American Museum of Natural History in New York, are by Mr. Rudolph Weber, the well-known artist of that institution. Wherever drawings have been reproduced from previous publications full credit is given in the text and plates.

As preparators employed upon this material under the direction of Professor Marsh, Messrs. Adam Hermann and Hugh Gibb rendered especially valuable service.

JOHN B. HATCHER.